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Music of the Heavens Turns Out to Sound a Lot Like a B Flat

By DENNIS OVERBYE

Astronomers say they have heard the sound of a black hole singing. And what it is singing, and perhaps has been singing for more than two billion years, they say, is B flat — a B flat 57 octaves lower than middle C.

The "notes" appear as pressure waves roiling and spreading as a result of outbursts from a supermassive black hole through a hot thin gas that fills the Perseus cluster of galaxies, 250 million light-years distant. They are 30,000 light-years across and have a period of oscillation of 10 million years. By comparison, the deepest, lowest notes that humans can hear have a period of about one-twentieth of a second.

The black hole is playing "the lowest note in the universe," said Dr. Andrew Fabian, an X-ray astronomer at the Institute for Astronomy at Cambridge University in England.

Dr. Fabian was the leader on an international team that used NASA's Chandra X-ray Observatory to detect the black hole's notes as ripples of luminosity in the X-ray glow of the cluster. The discovery, announced last week at NASA headquarters in Washington and in a paper in the journal Monthly Notices of Royal Astronomical Society, might help solve longstanding problems regarding the structure of galaxy clusters, the largest, most massive objects in the universe, and the evolution of galaxies within them, astronomers said.

Far from being "just an interesting form of black hole acoustics," as Dr. Steven Allen of the Institute of Astronomy said in a news release, the sound waves might be the key to figuring out how such clusters grow.

Black holes, as decreed by Einstein's general theory of relativity, are objects so dense that neither light nor anything else, including sound, can escape them. But long before any sort of material disappeared into a black hole, theorists have surmised, it would be accelerated to near-light speeds by the hole's gravitational field and heated to millions of degrees as it swirled in a dense doughnut around the gates of doom, sparking X-rays and shock waves and squeezing jets of energy and particles across space.

Such furiously feeding black holes are thought to be the engines responsible for the violent quasars and other phenomena in the cores of galaxies. The new work suggests that such black holes can exert influences far beyond their host galaxies.

The biggest clusters, like the one in Perseus, can contain thousands of galaxies and trillions of stars. Paradoxically, most of the ordinary matter in them resides not in stars, but in intergalactic gas that has been heated by the fall into the cluster to temperatures of 50 million degrees or so. The gas glows brightly enough in X-rays to be seen far across the universe. Cosmologists use this X-ray glow to find clusters in the deep of spacetime.

It has long been a puzzle what keeps the cluster gas hot. Without a continuing input of energy, the gas at the

center would radiate its heat, lowering its pressure, and cooler gas would flow in from the outskirts, providing fresh fuel to make stars.

"We should see stars forming in central galaxies," said Dr. Kimberly Weaver, an astronomer at the Goddard Space Flight Center in Greenbelt, Md. But they do not, she said.

Astronomers, Dr. Fabian said, suspected that black holes in the central galaxies of clusters might be keeping the cluster gas hot, but the astronomers did not know how.

As the brightest X-ray cluster in the sky, radiating 1,000 times as much energy in X-rays as visible light, Perseus is a logical laboratory for investigating the problem, Dr. Fabian explained. A particularly massive black hole is believed to lurk in a galaxy known as NGC 1275, which lies at the center of the cluster.

Two jets of radio energy shooting out of the galaxy's nucleus have blown two bubbles in the gas in the center of the cluster. In an X-ray image from the Chandra satellite released three years ago, these bubbles looked like the eyeholes of a giant eerie orange skull.

Last year, however, Dr. Fabian and his colleagues obtained a new long-exposure Chandra image of the Perseus cluster, which showed waves moving outward like ripples on a pond from the central bubbles.

The waves, they realized, might be the ideal missing link between the jets and the surrounding gas. Dr. Fabian compared the process to a child's blowing bubbles in a glass of water through a straw. In this case, the jets are the straw. The bubbles pushing against the enormous pressure of the gas surrounding them create sound waves moving out through the cluster's gas, pumping energy into it and heating it.

Other astronomers called the results beautiful, but said more study was needed to confirm that the wave process could be supplying the missing energy to the cluster. "I think it might be," said Dr. Simon White of the Max Planck Institute for Astrophysics in Garching, Germany.

The energies are as prodigious as the symphony is boring. It takes the energy of 100 million supernova explosions to blow a central bubble in the cluster. If the black hole blows such bubbles continuously and it is this energy that has been keeping Perseus hot, then the black hole in Perseus must have been playing a steady B flat for a long time, said Dr. Fabian. "It's the longest-lasting symphony we know of," said Dr. Bruce Margon, an astronomer at the Space Telescope Science Institute.